Practical Approaches to the Analysis of MEG Data Sets

MEG data are usually NOT ambiguous – ~~"inverse problem"~~

Learn to read your signals!
Put effort in experimental design and measurement!

Experimental Paradigms

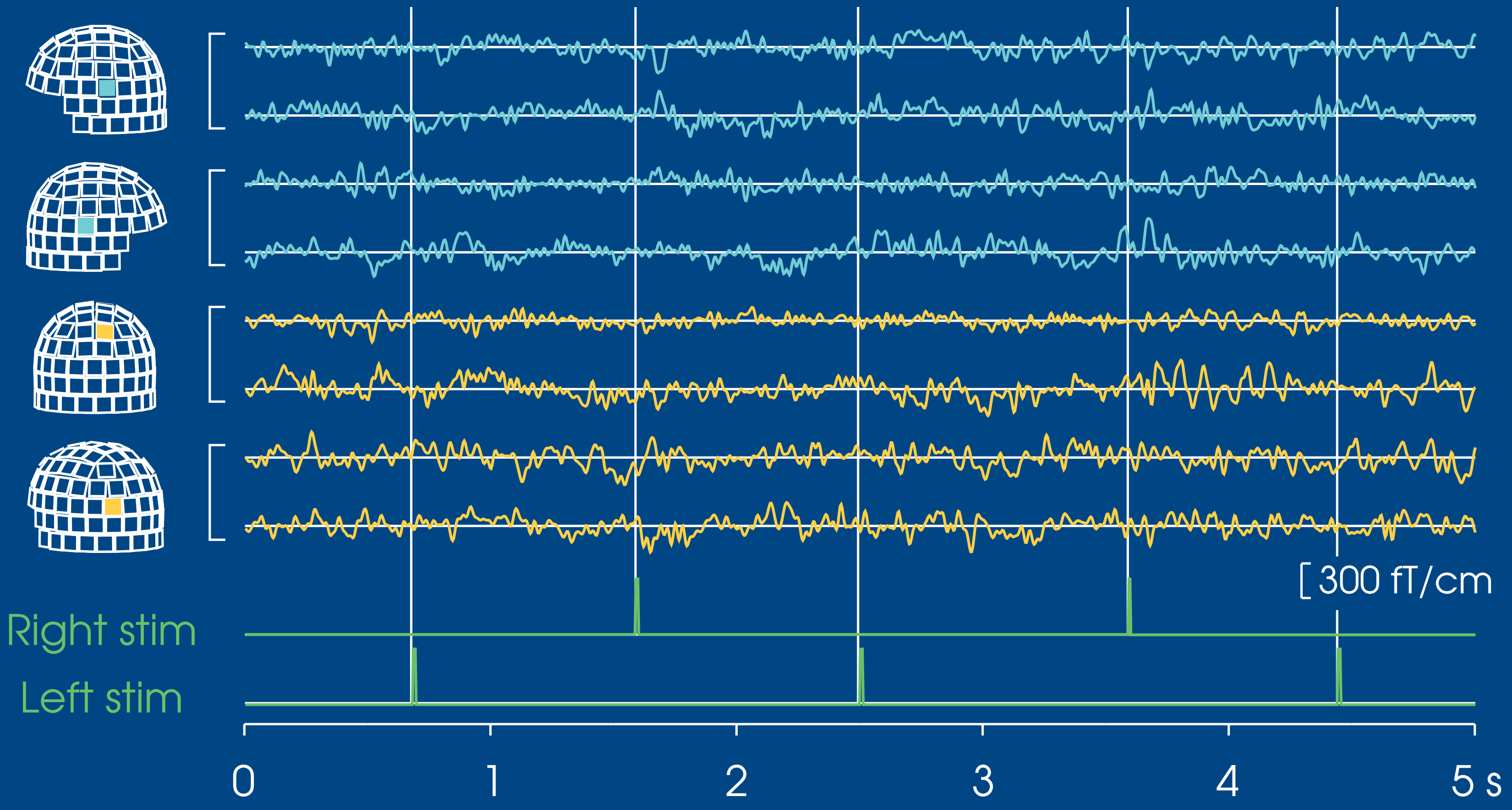
Auditory stimulation

Somatosensory stimulation

Reading silently

Reading aloud

Normal Subject, Listening to Tones



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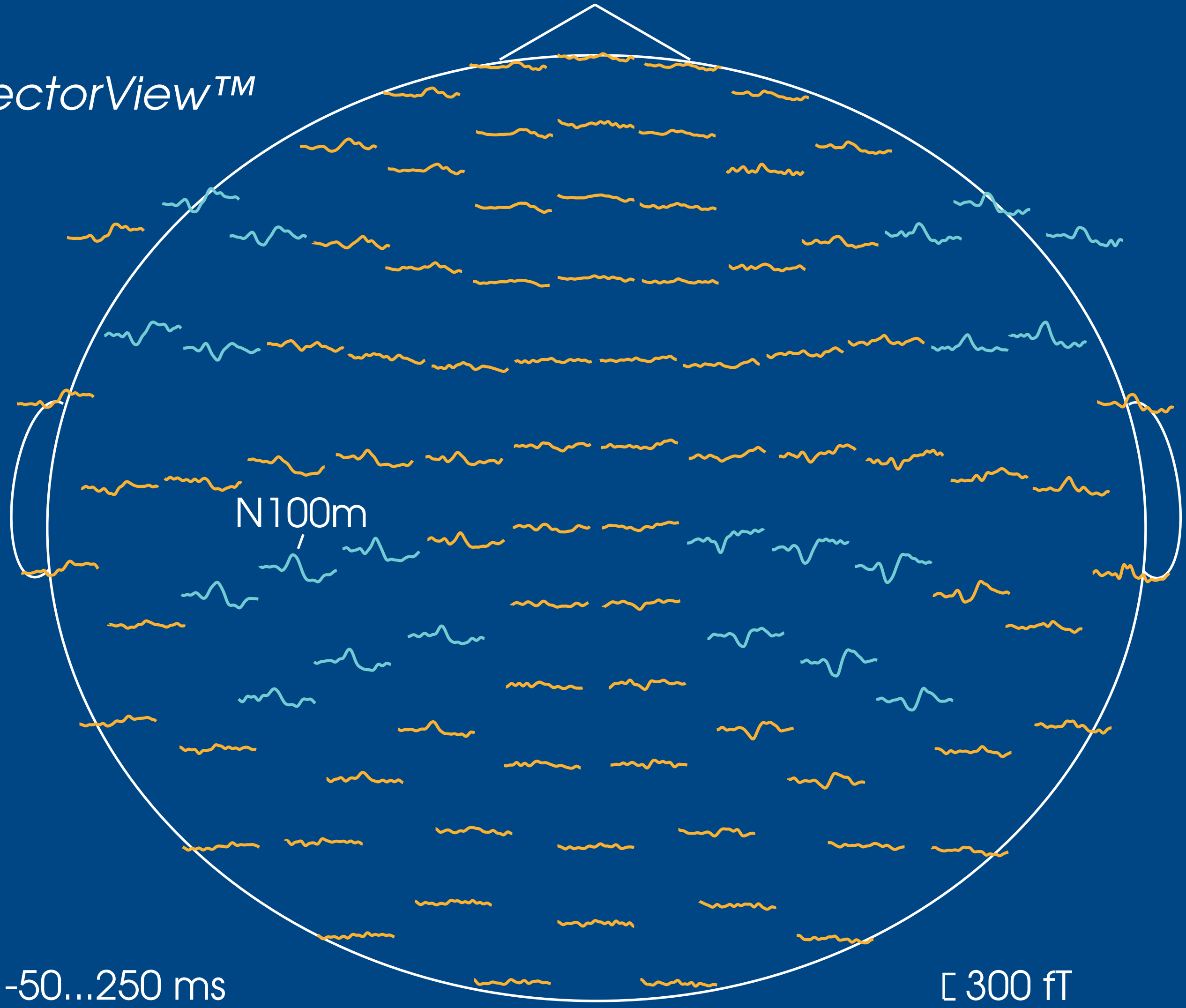
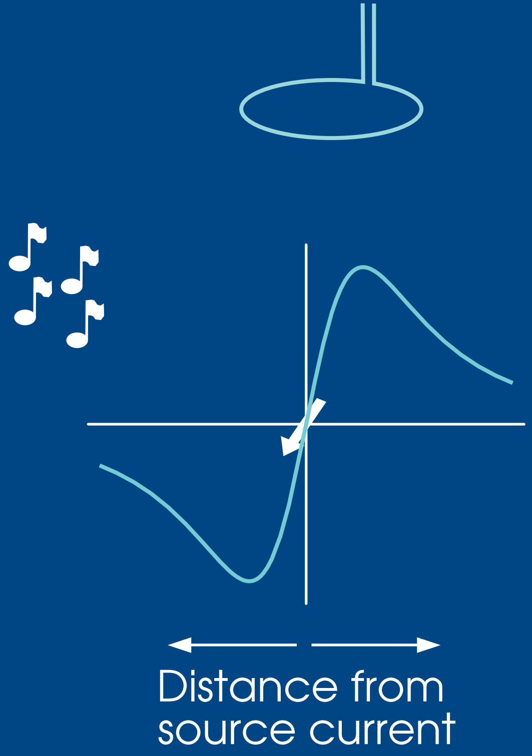
Auditory Responses: Magnetometers

VectorView™





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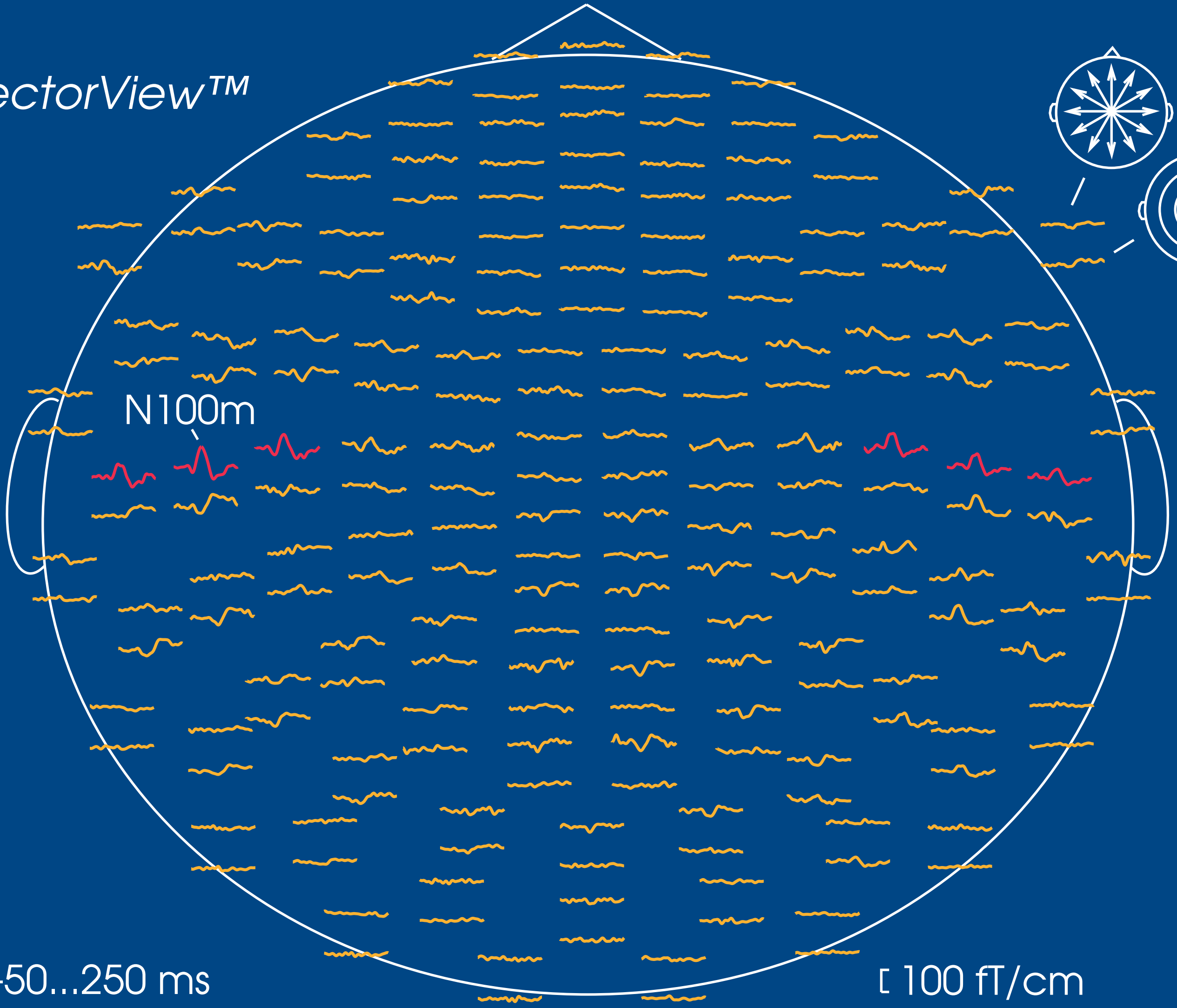
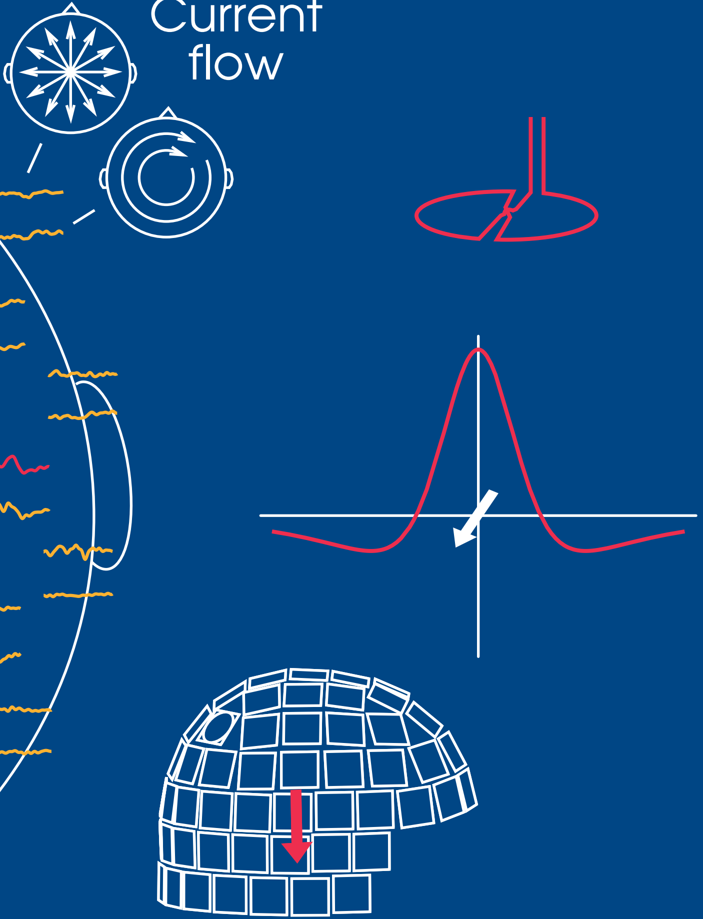
Auditory Responses: Planar Gradiometers

VectorView™





-50...250 ms

100 fT/cm

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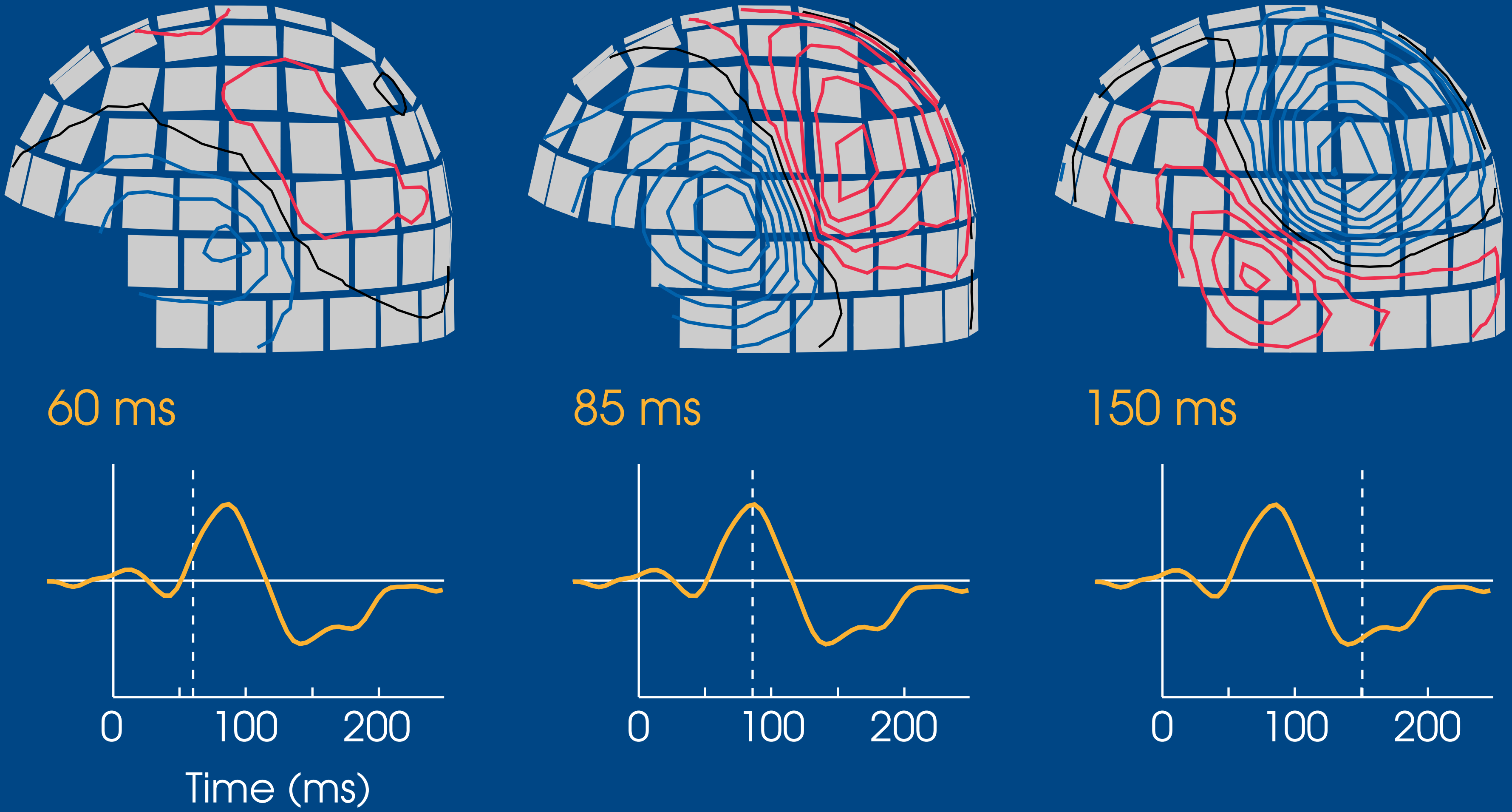
Auditory Responses: Field Patterns



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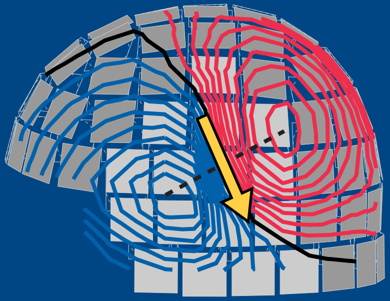
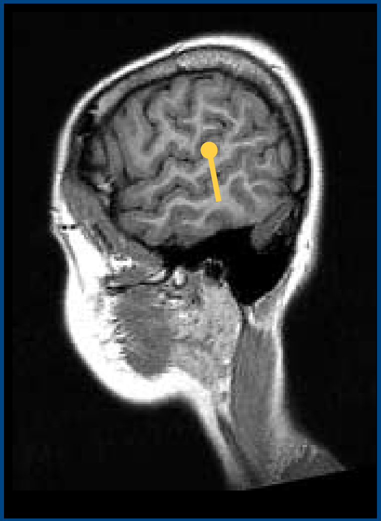
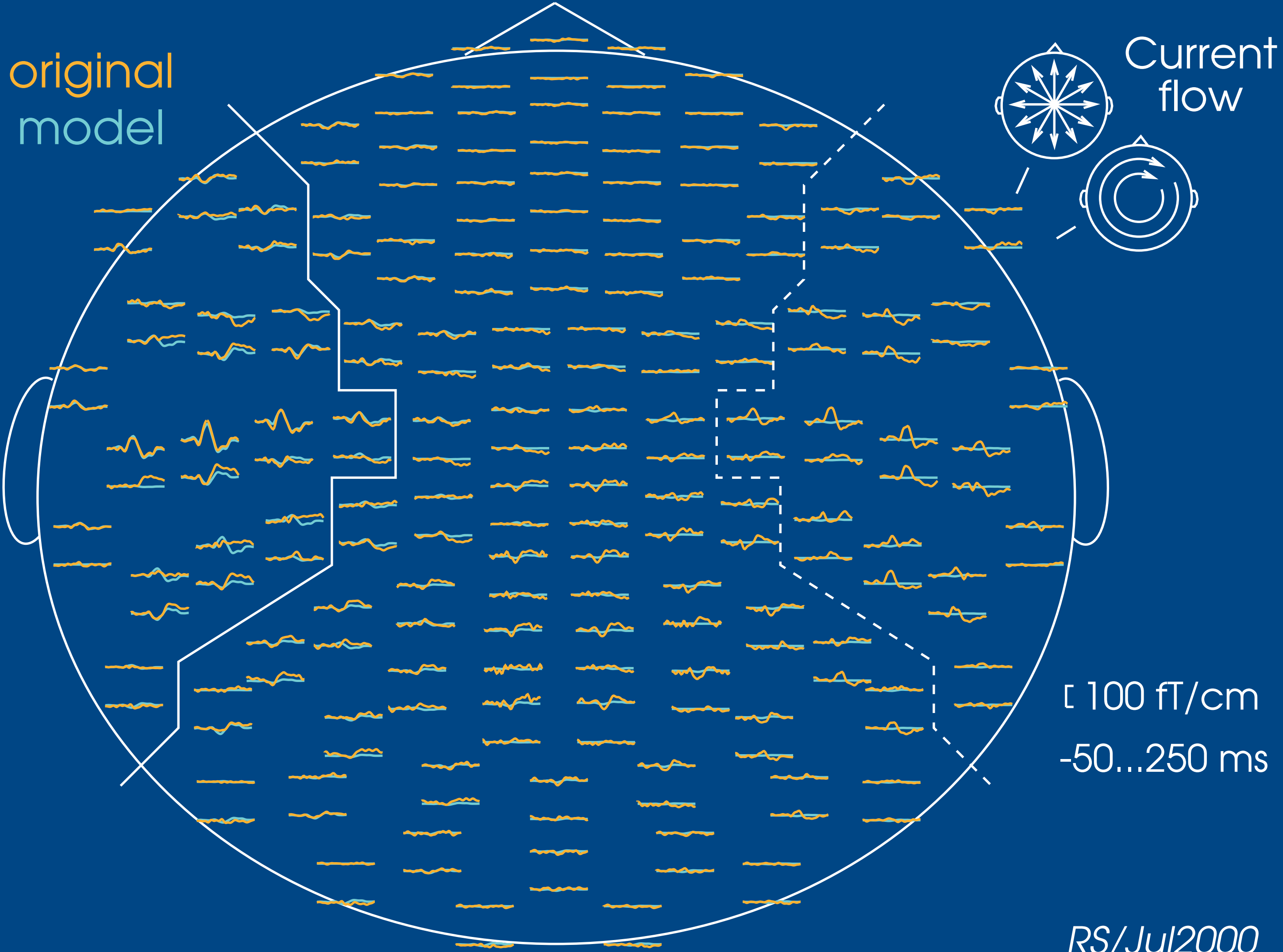
Auditory Responses: Finding Source Areas







original
model

Current flow

100 fT/cm

-50...250 ms

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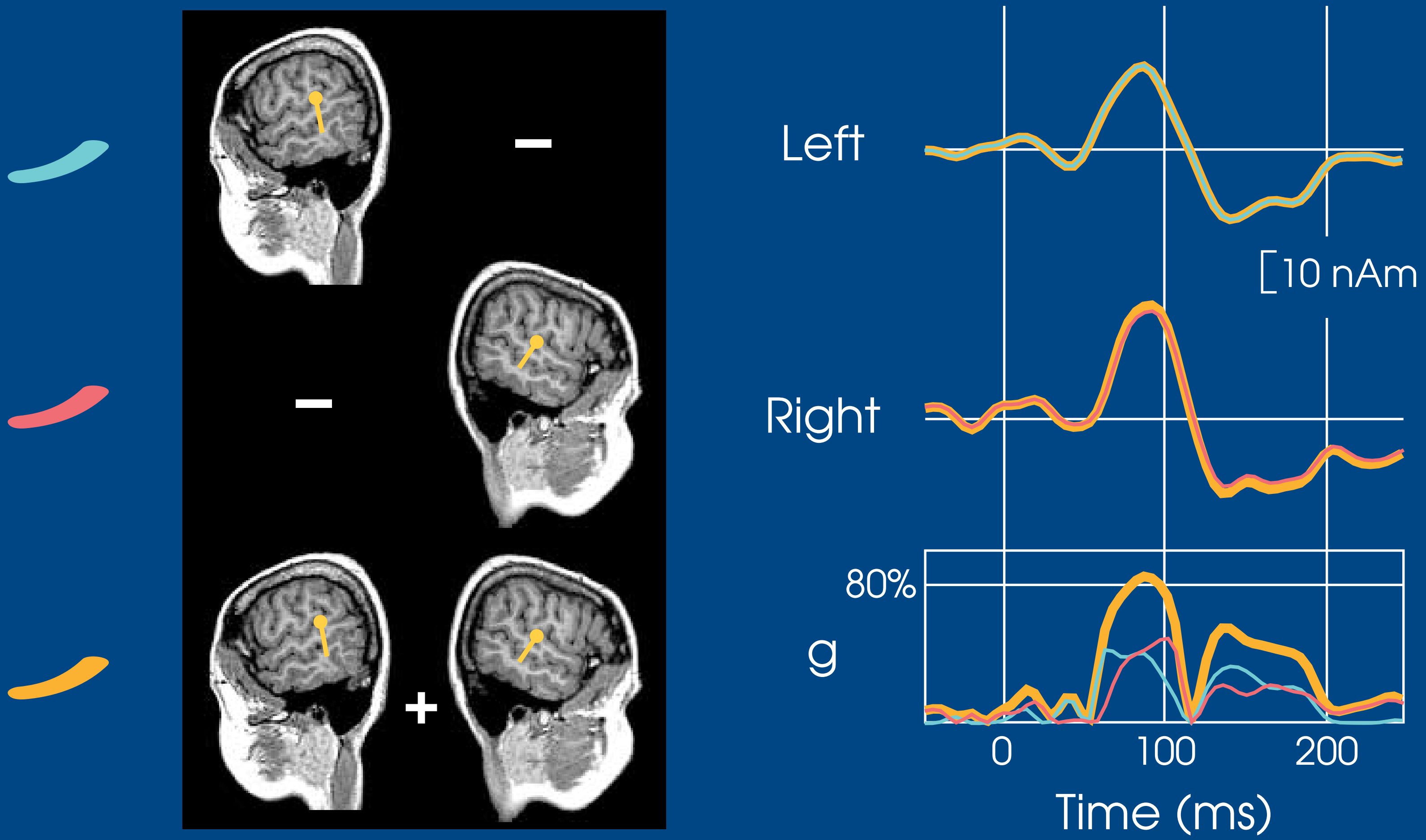
Auditory Responses: Multiple Sources



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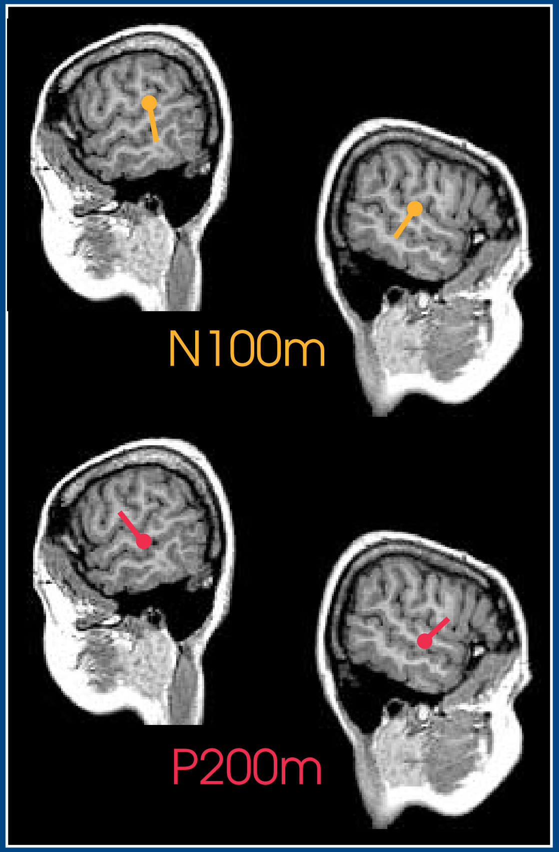
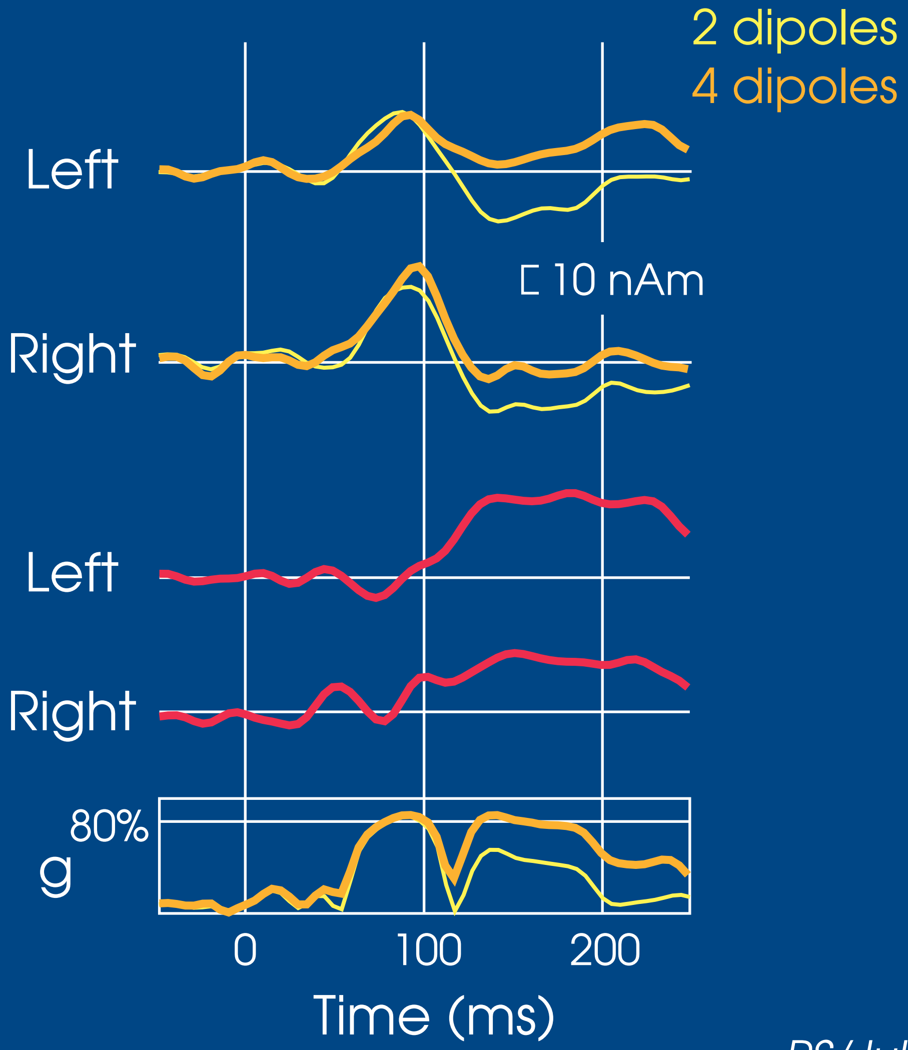
Auditory Responses: Multiple Sources





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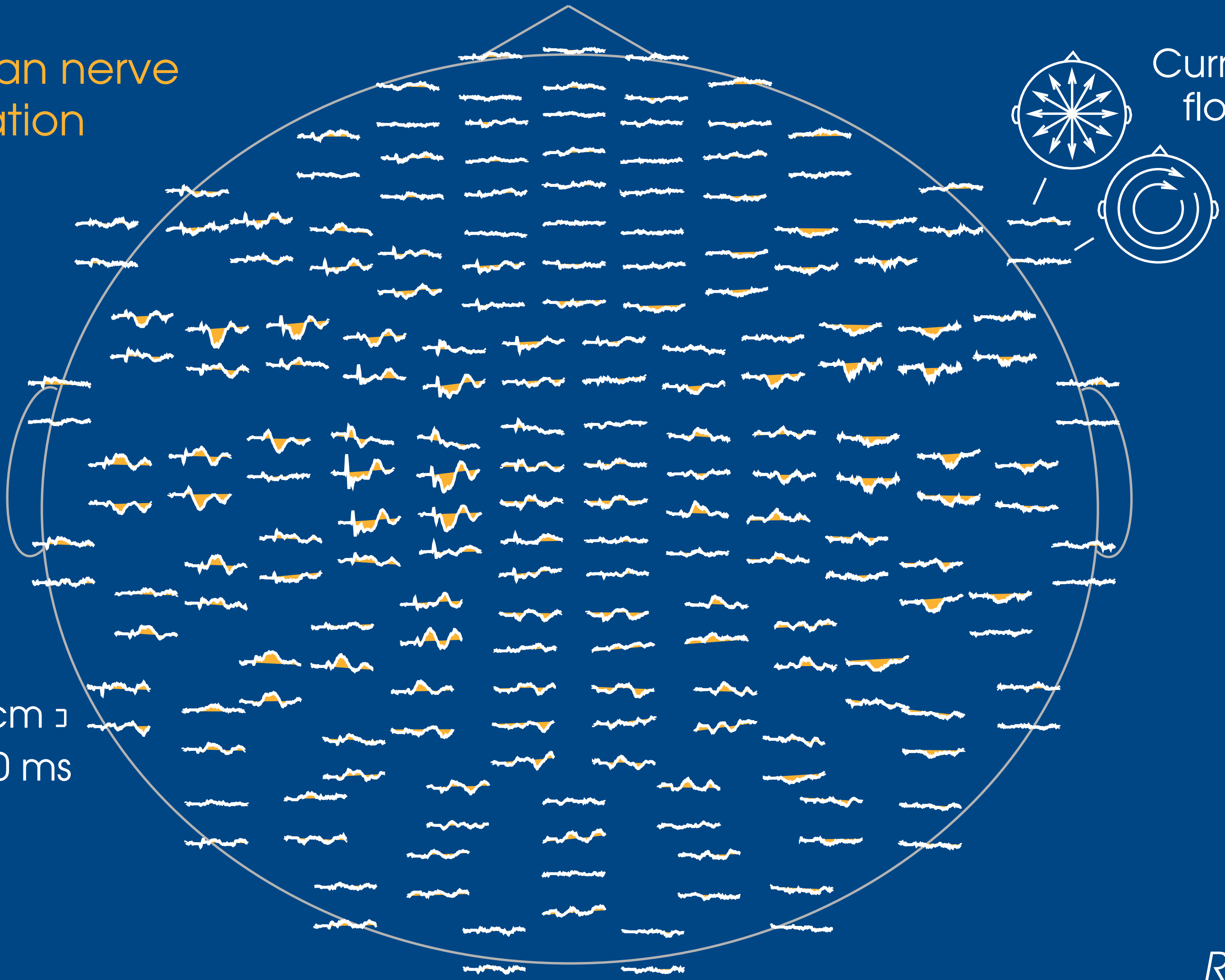
Somatosensory Responses: Signals

Right median nerve stimulation



Current flow

100 fT/cm

-50...250 ms

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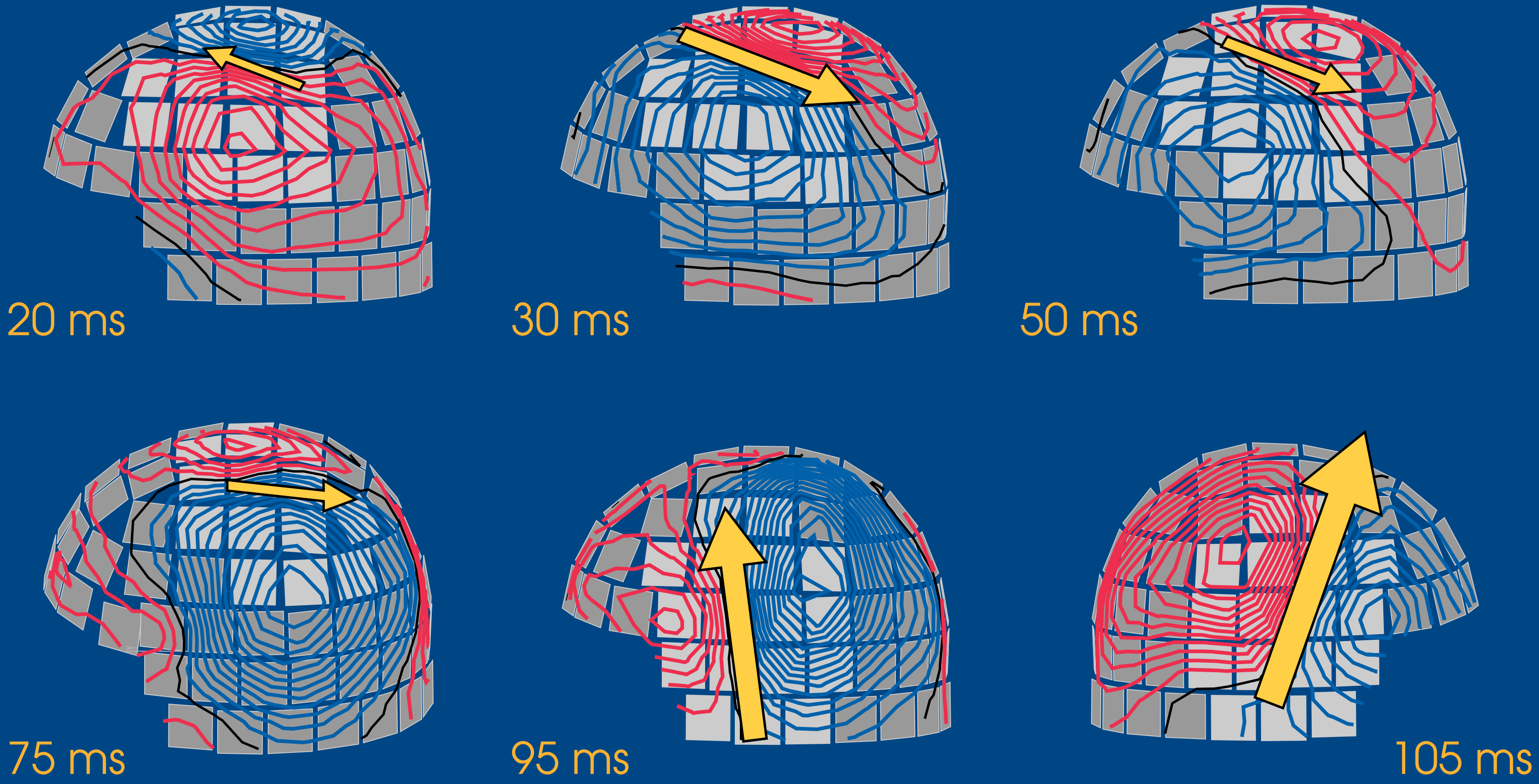
Somatosensory Responses: Field Patterns



20 ms

30 ms

50 ms

75 ms

95 ms

105 ms

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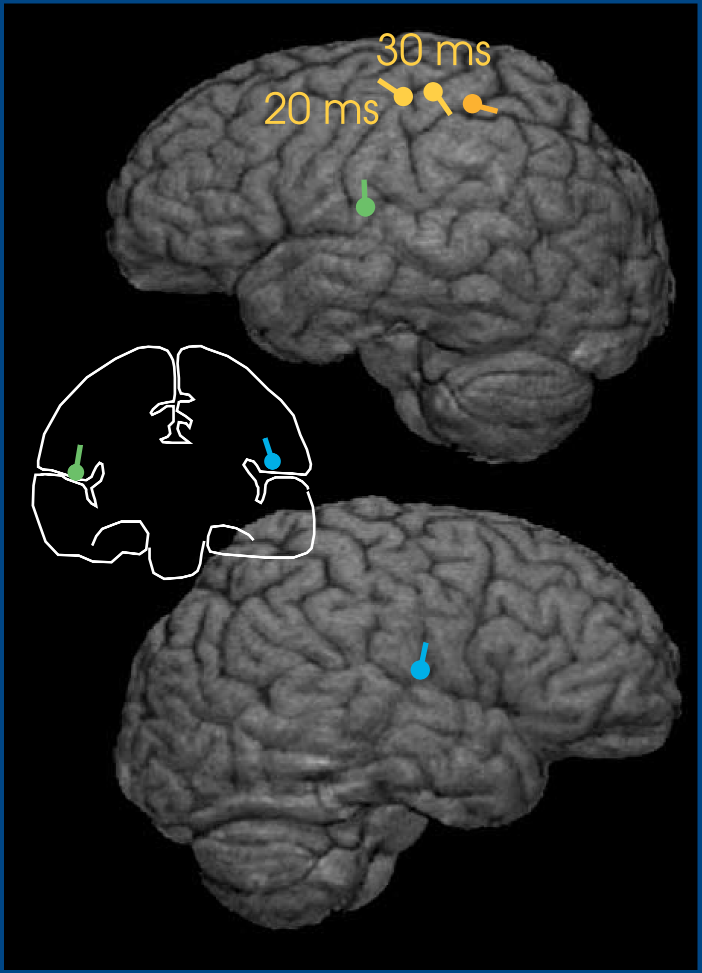
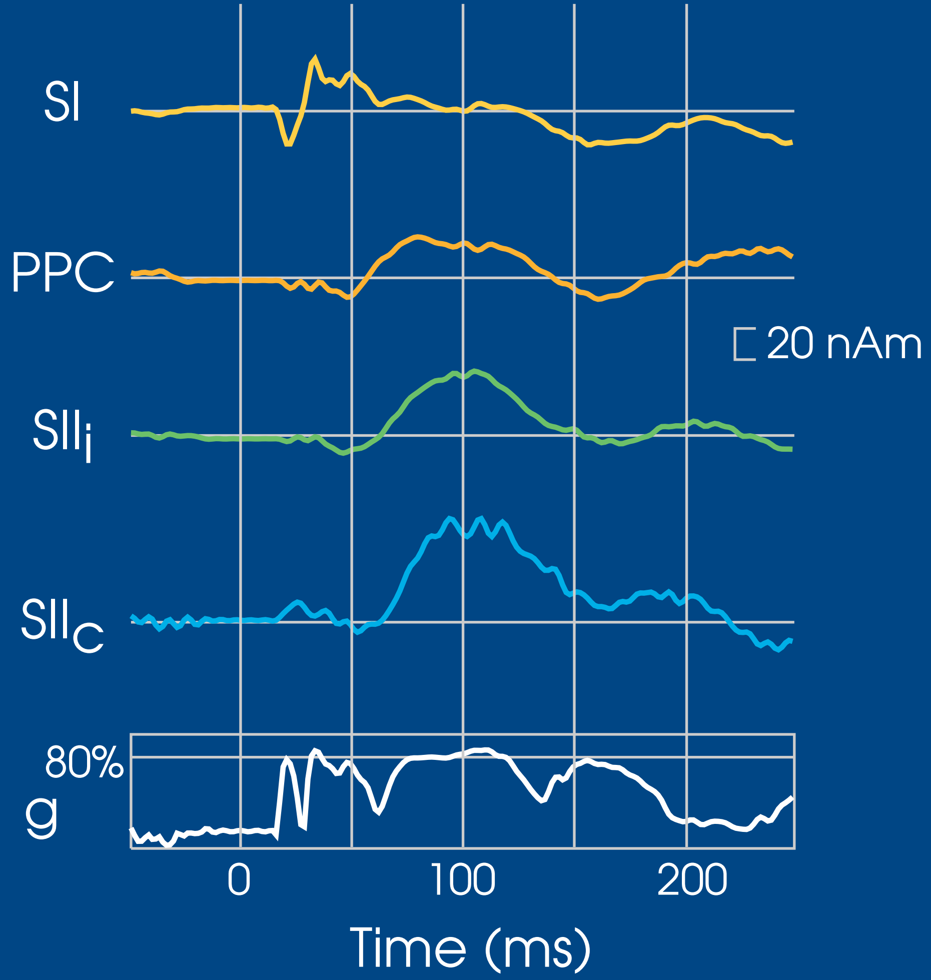
Somatosensory Responses: Source Waveforms





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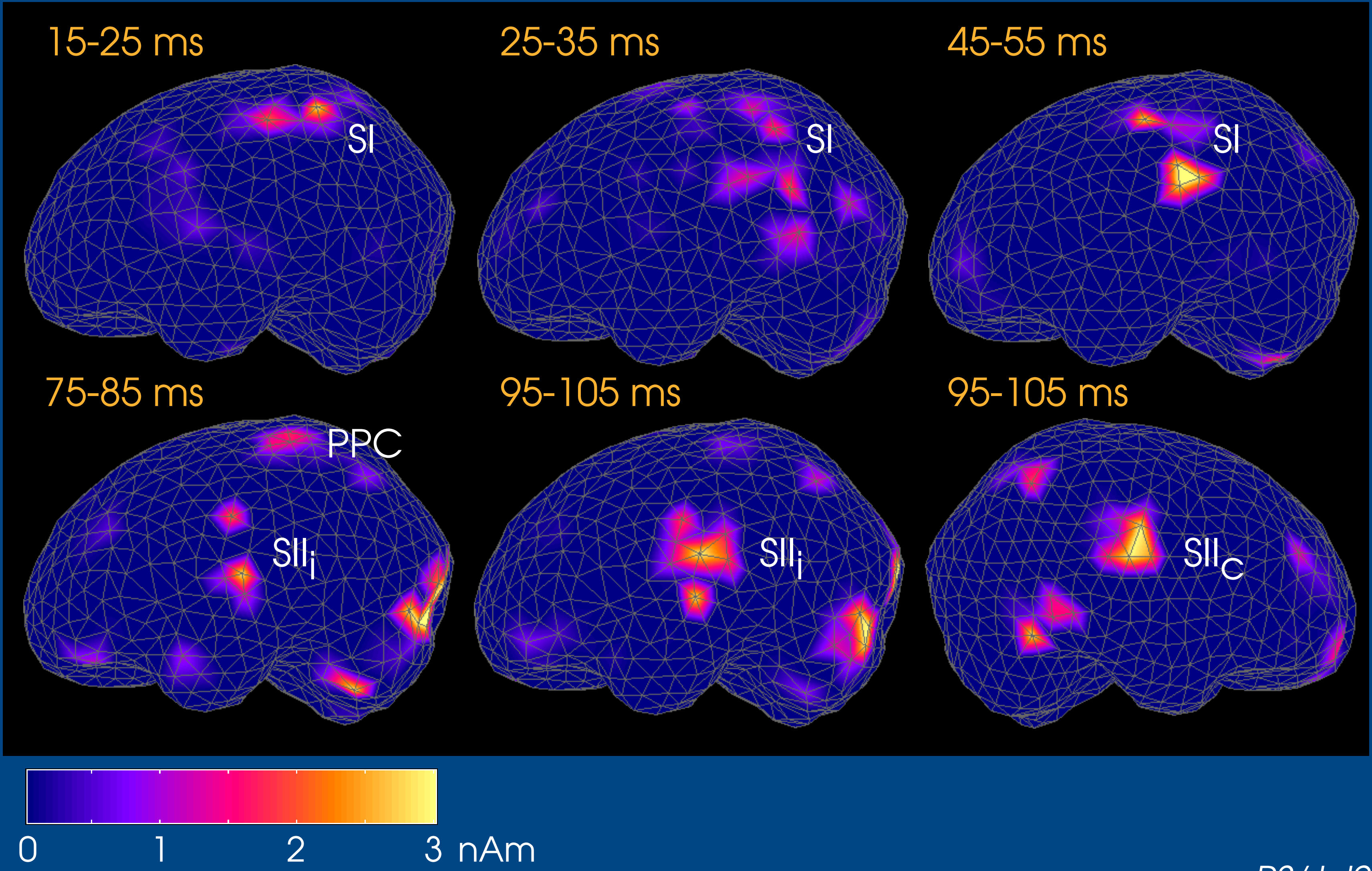
Somatosensory Responses: MCE Analysis



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Reading Words and Nonwords

Stimulus type	Example	
Short words	TALO	(house)
Long words	LAUTANEN	(plate)
Short nonwords	ROKI	
Long nonwords	SOIJINTO	

Lexicality x length	Words	Short = Long
	Nonwords	Short ≠ Long

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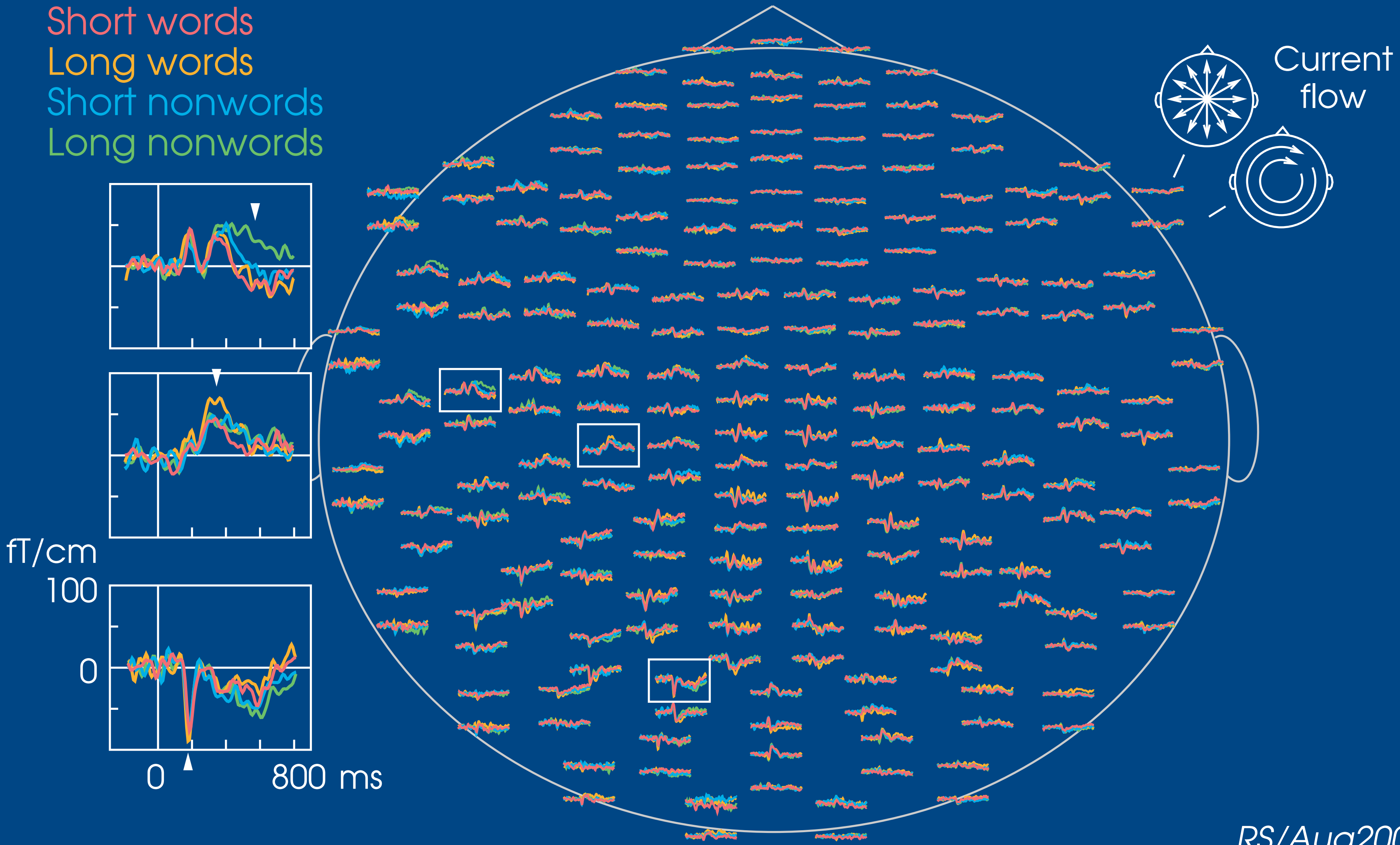
Reading Words and Nonwords: Signals



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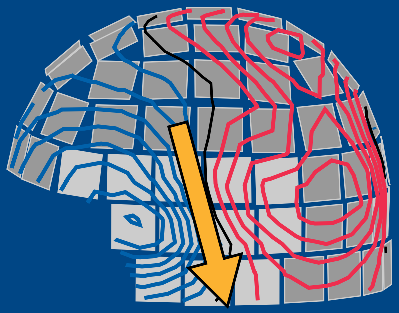
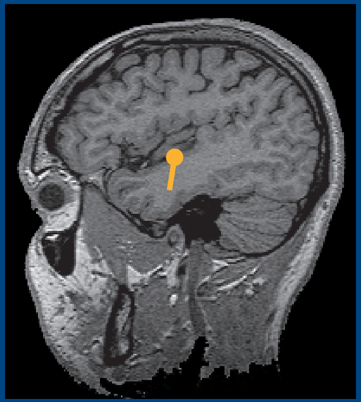
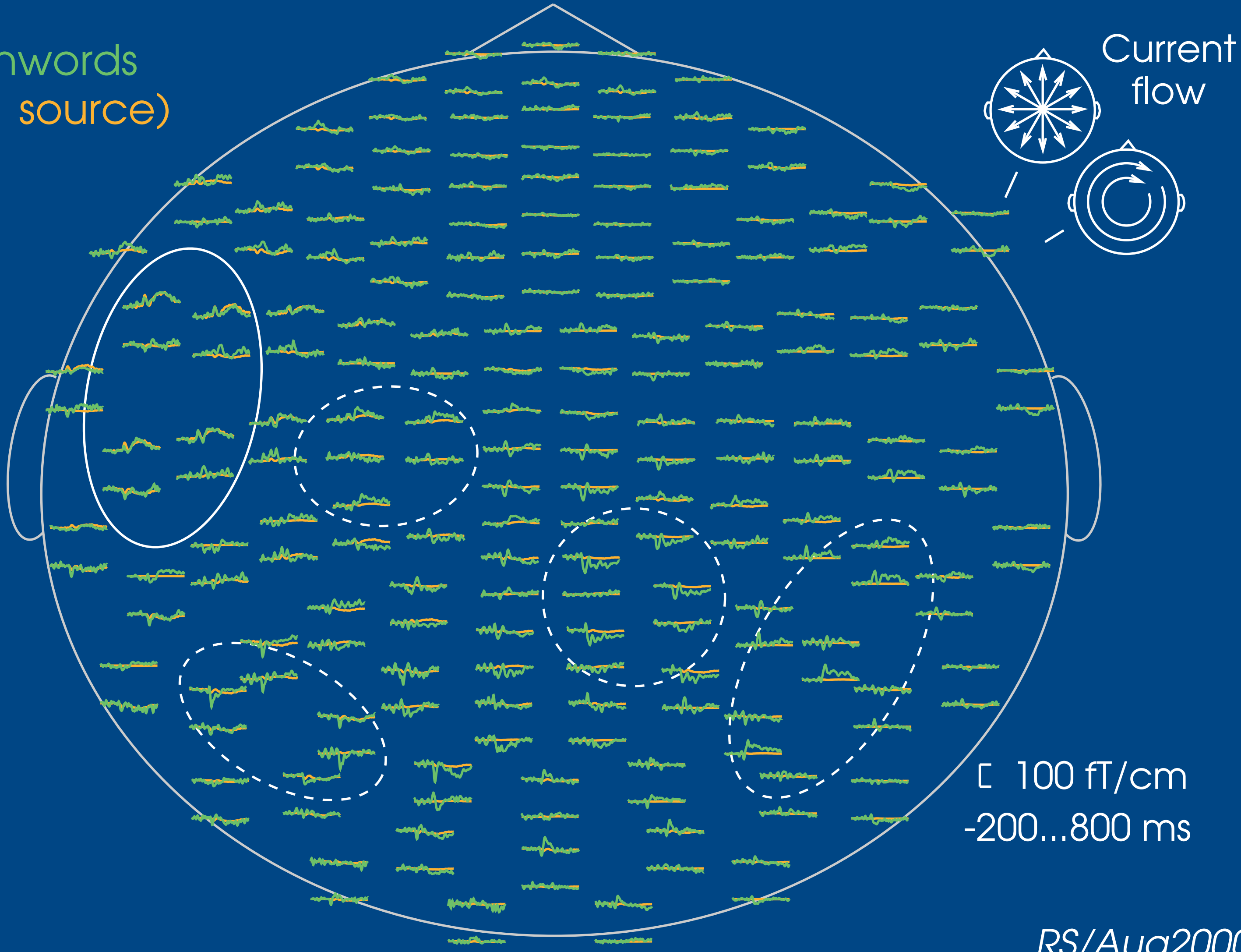
Reading Words and Nonwords: Source Modelling

Long nonwords
Model (1 source)







100 fT/cm
-200...800 ms

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Analysis of Multiple Data Sets: Approaches

1. Analyze each data set independently and COMBINE
   (e.g. short words, long words, short nonwords, long nonwords)

   Start from the most prominent response pattern
   the earliest
   Choose the sources with clearest field patterns/ best confidence values for the combined model

2. Start from one experimental condition, use these sources for the other conditions, and ADD and MODIFY sources

Separate sets of sources for each experimental condition:
Compare LOCATIONS and ORIENTATIONS of current flow

A single set of sources for all experimental conditions – as few as possible:
Compare ACTIVATION STRENGTHS and TIMING

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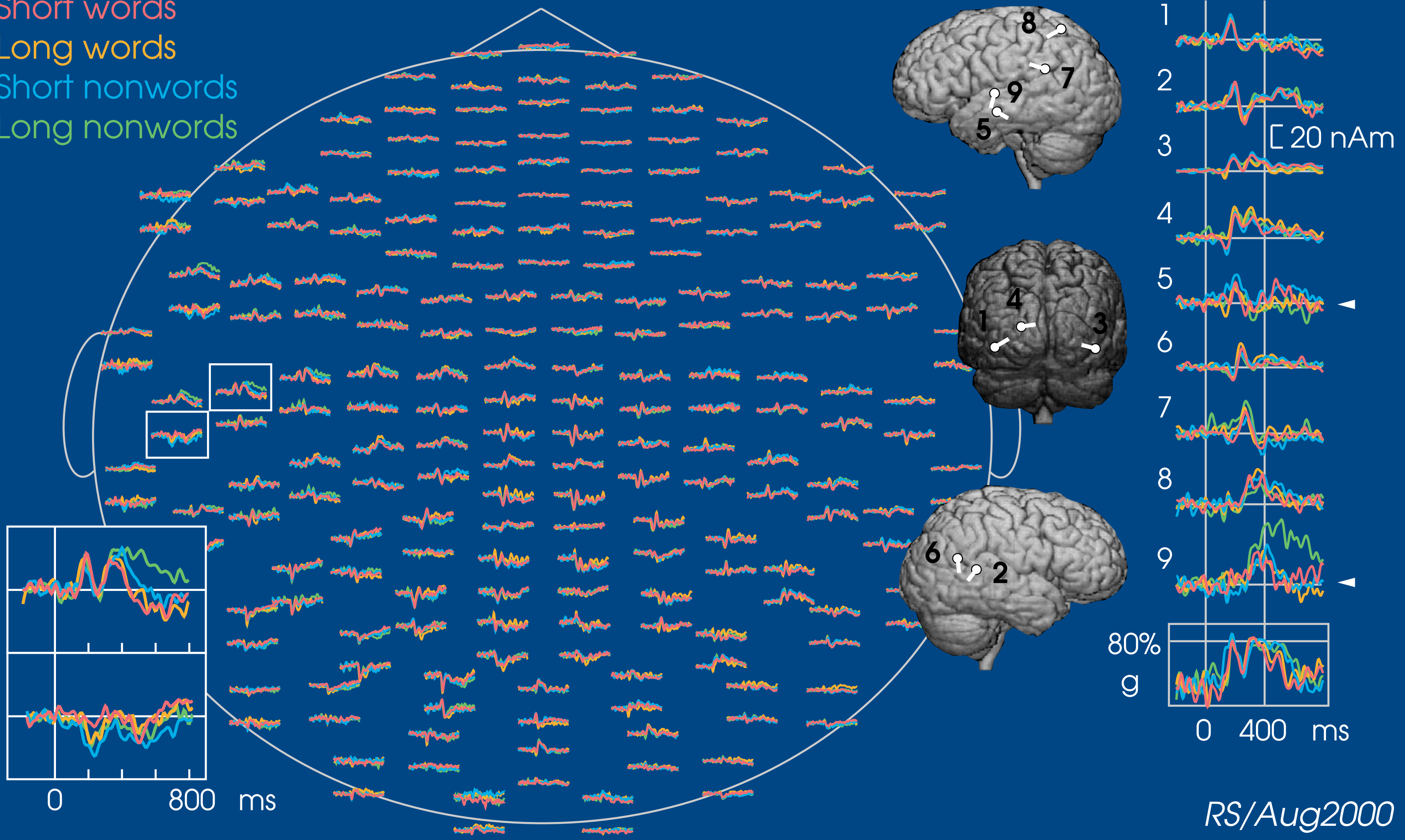
Reading Words and Nonwords: Signals *vs.* Model

Short words
Long words
Short nonwords
Long nonwords



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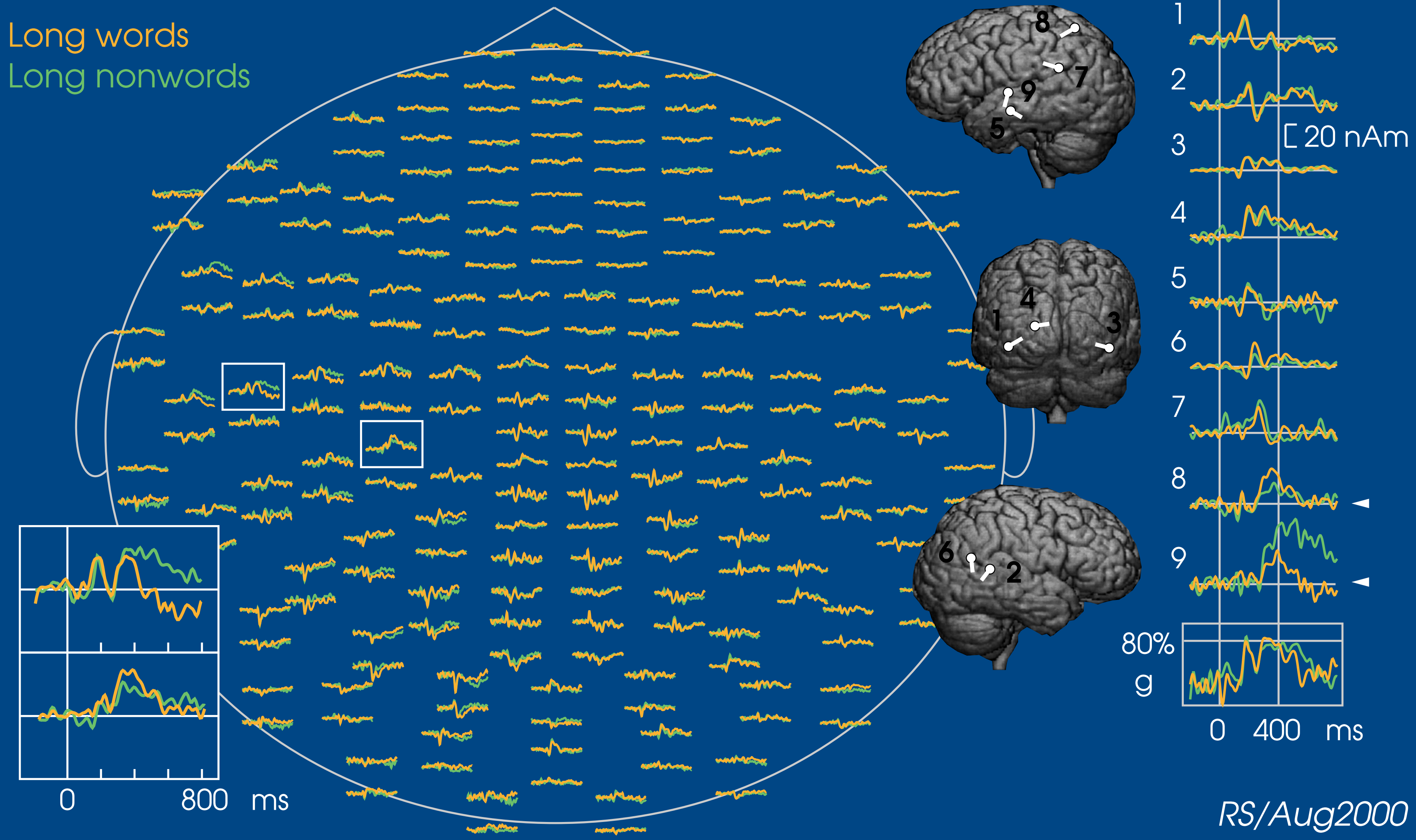
Reading Words and Nonwords: Signals *vs.* Model



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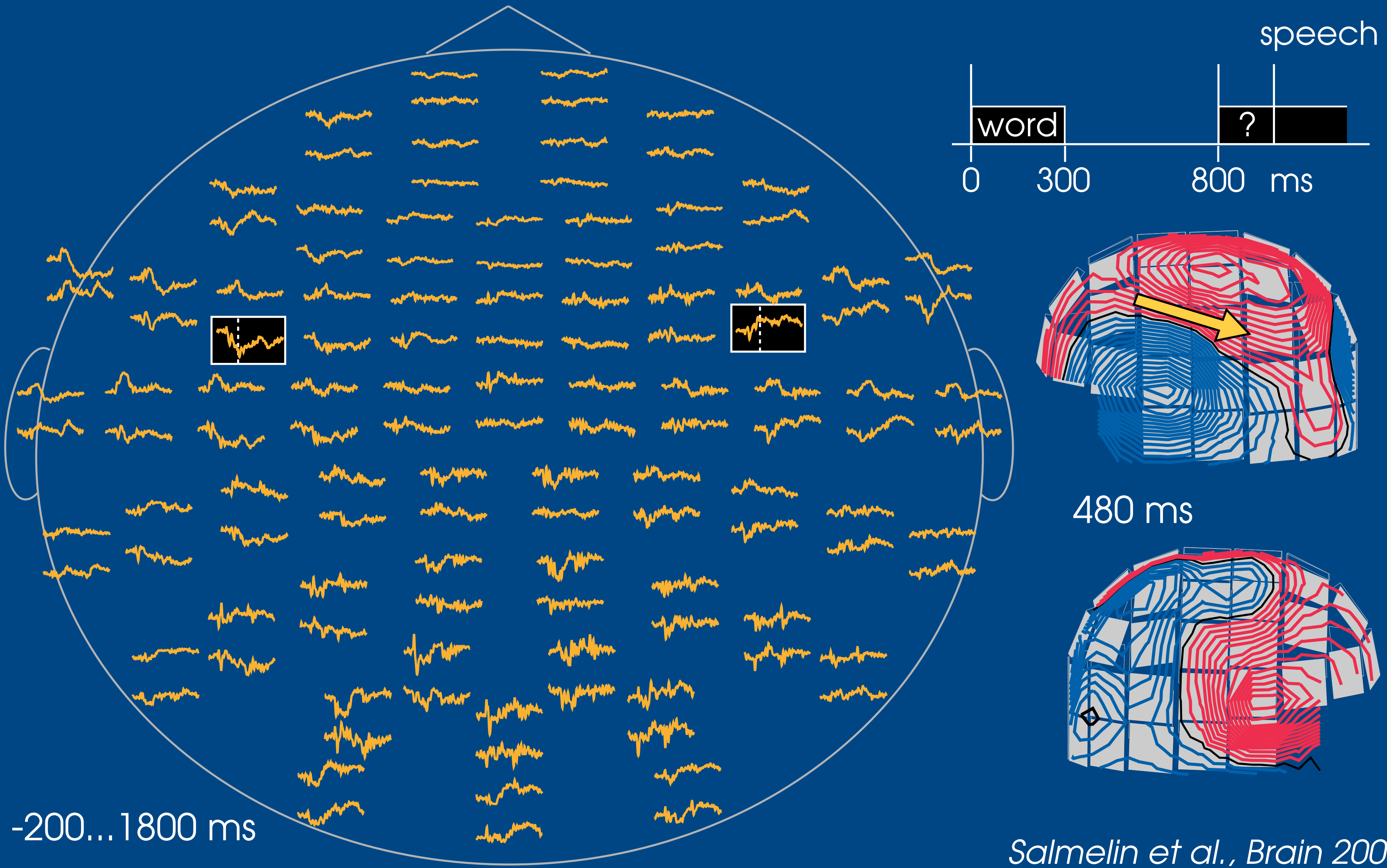
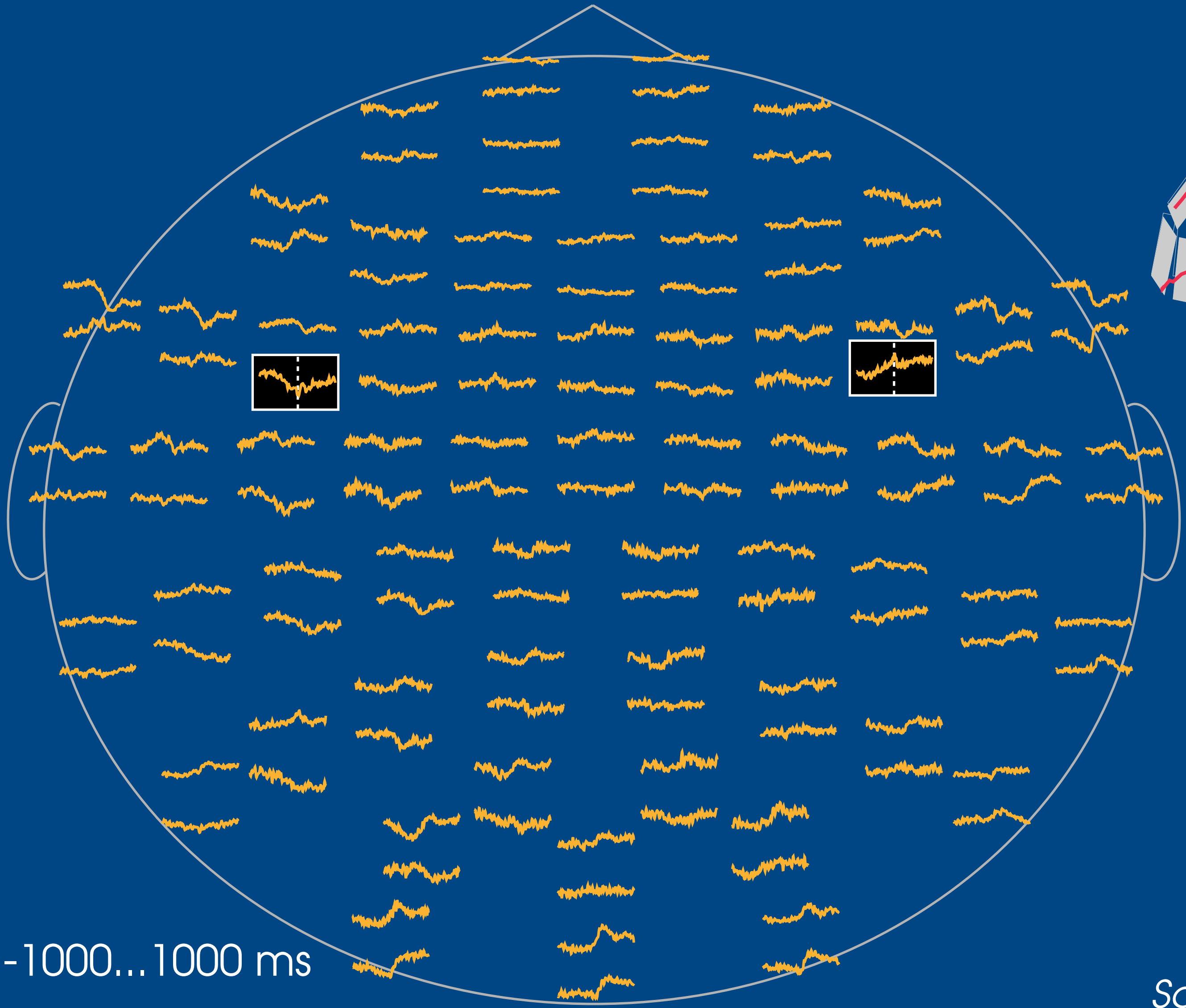
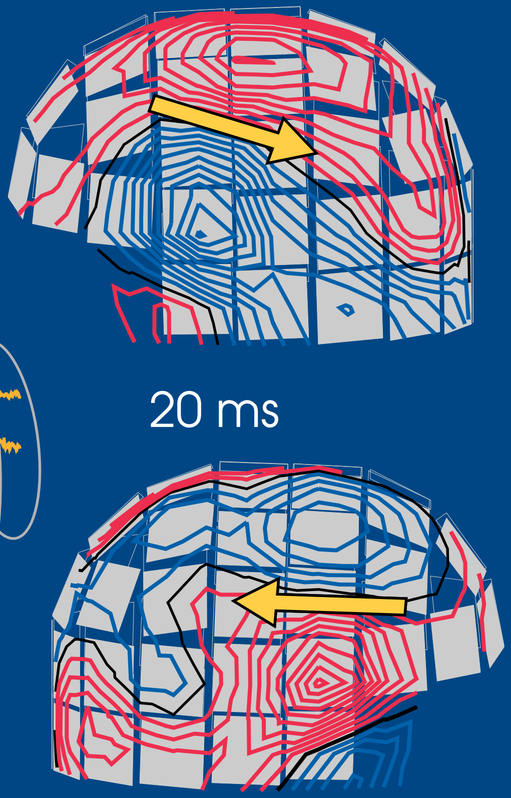
Reading Words Aloud: Stimulus Onset



Salmelin et al., Brain 2000

Reading Words Aloud: Mouth Movement Onset

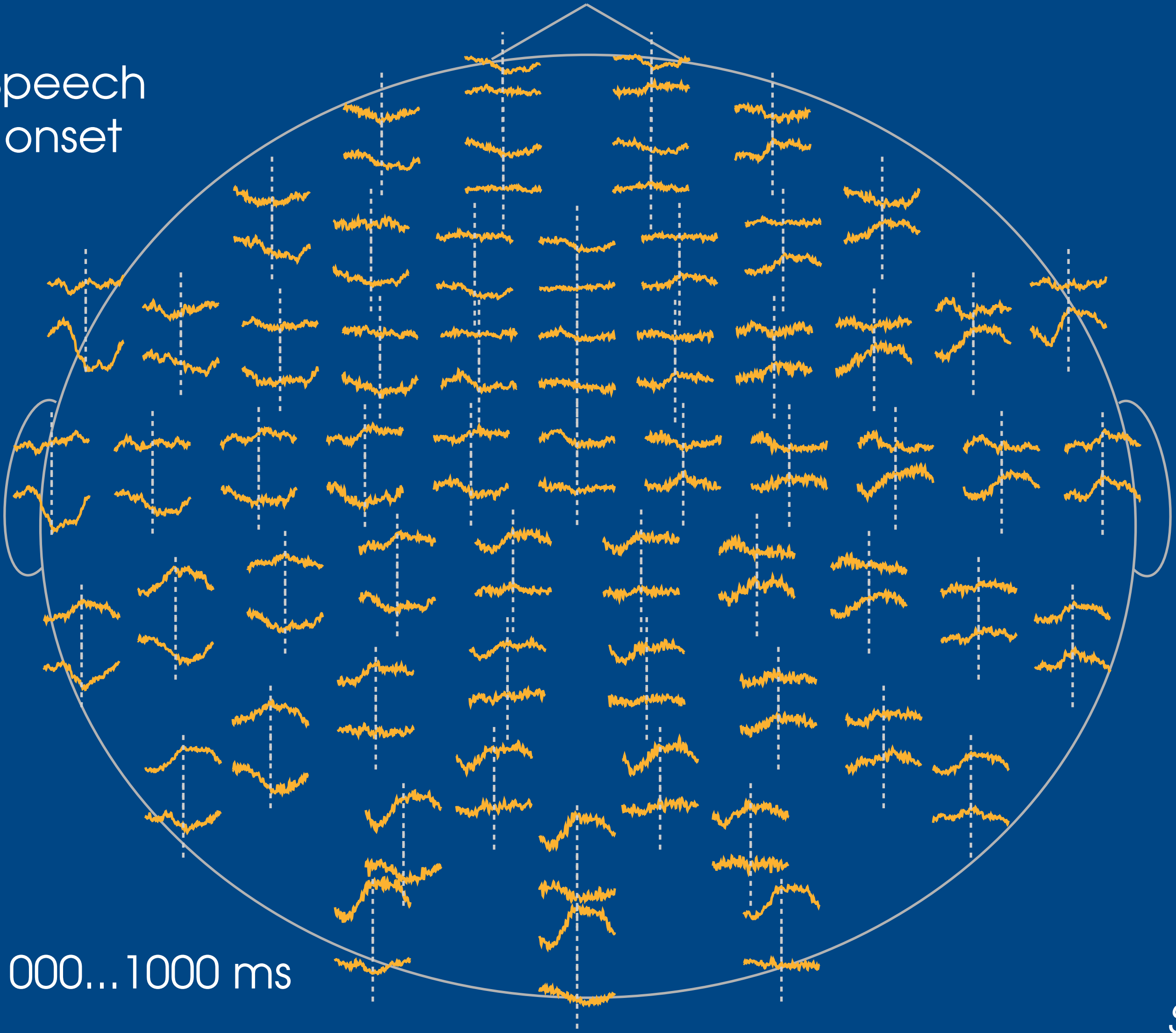




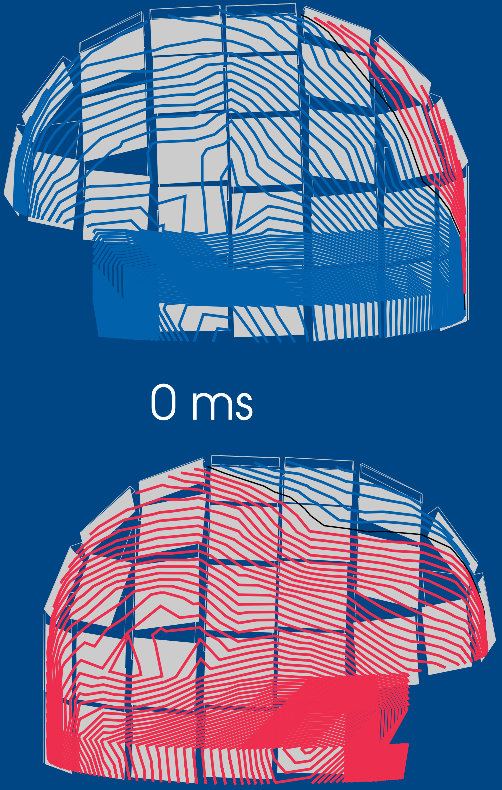
Salmelin et al., Brain 2000

Reading Words Aloud: Mouth Movement Artefact

Speech
onset



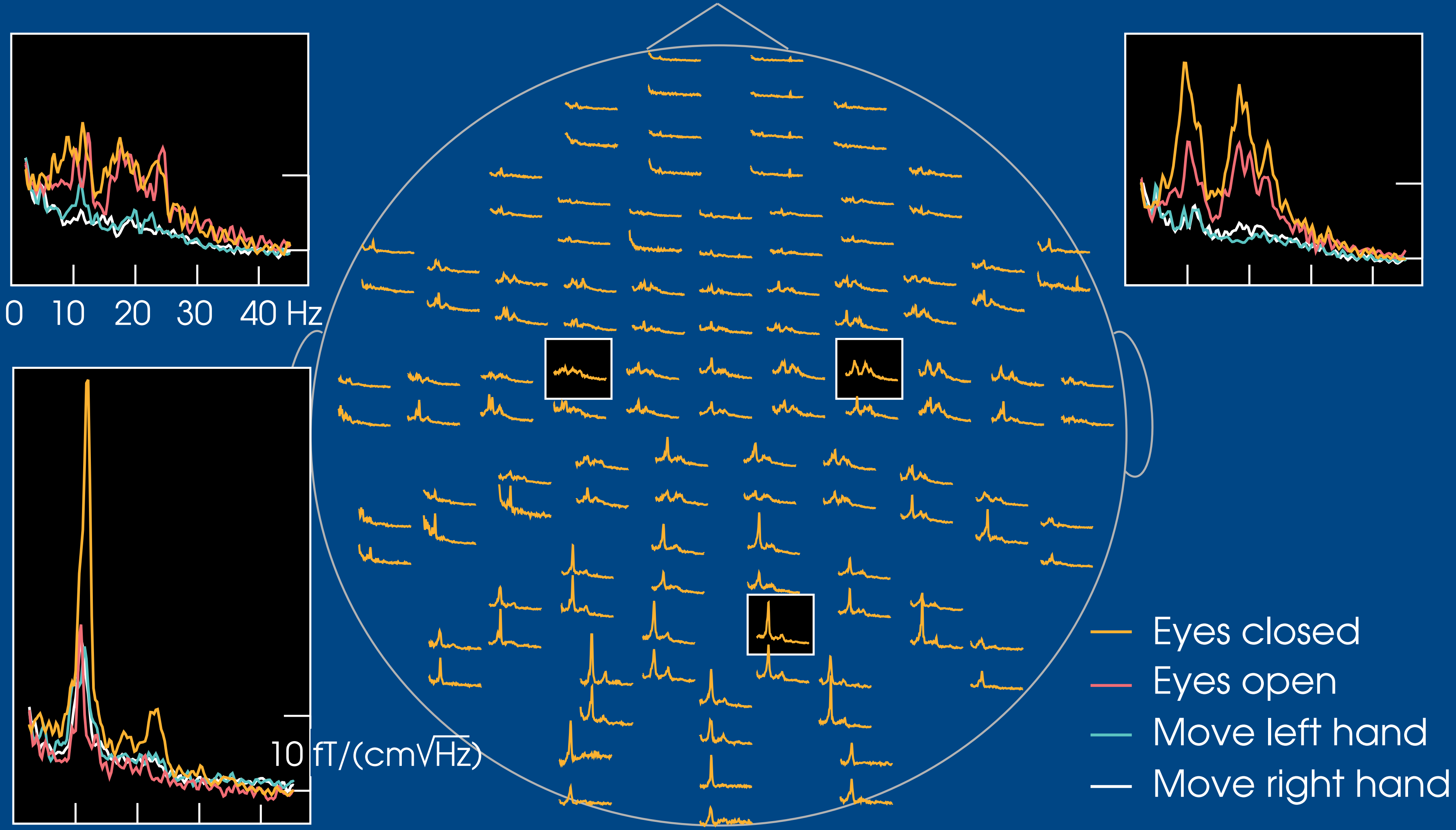
-1000...1000 ms



0 ms

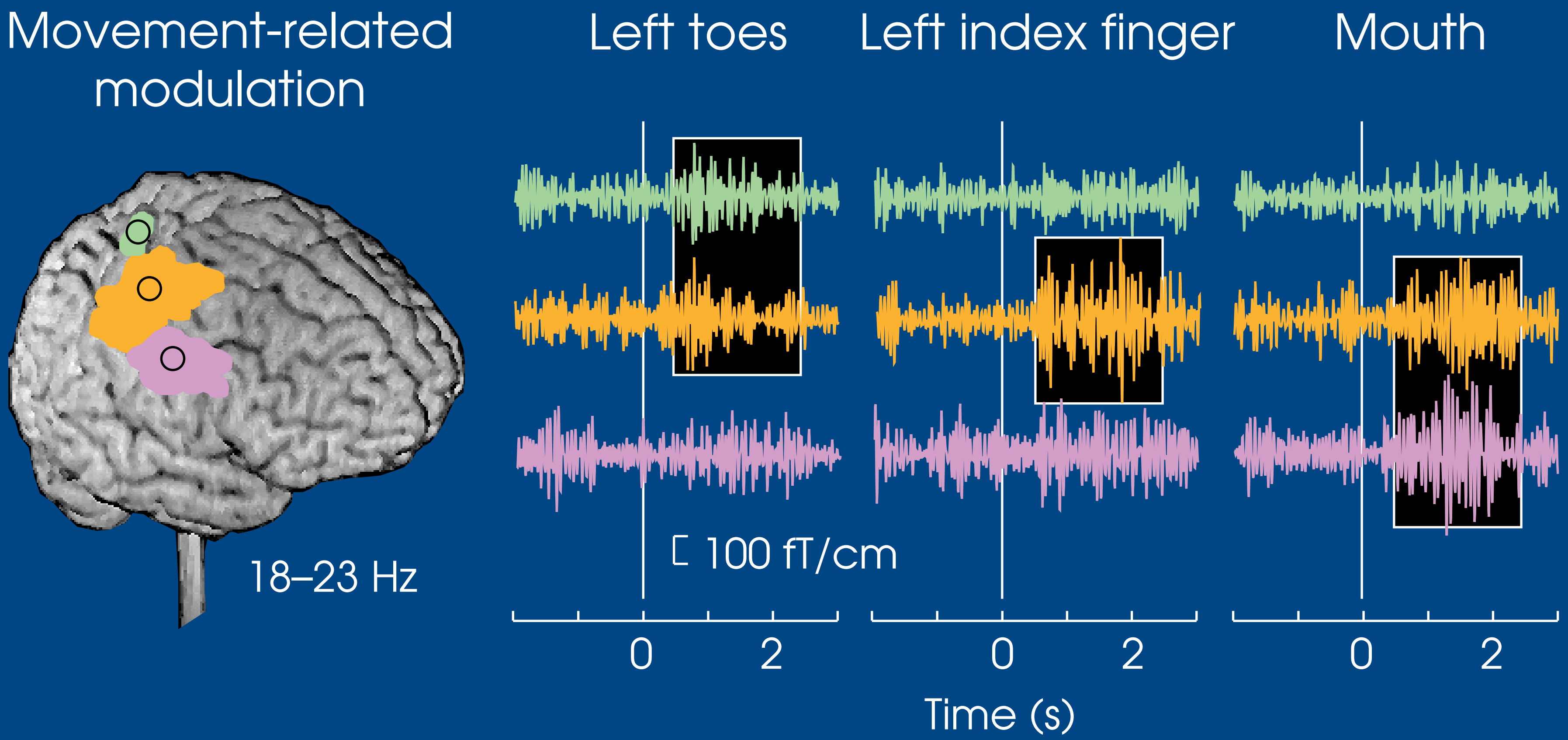
Salmelin et al., Brain 2000

Spectral Analysis



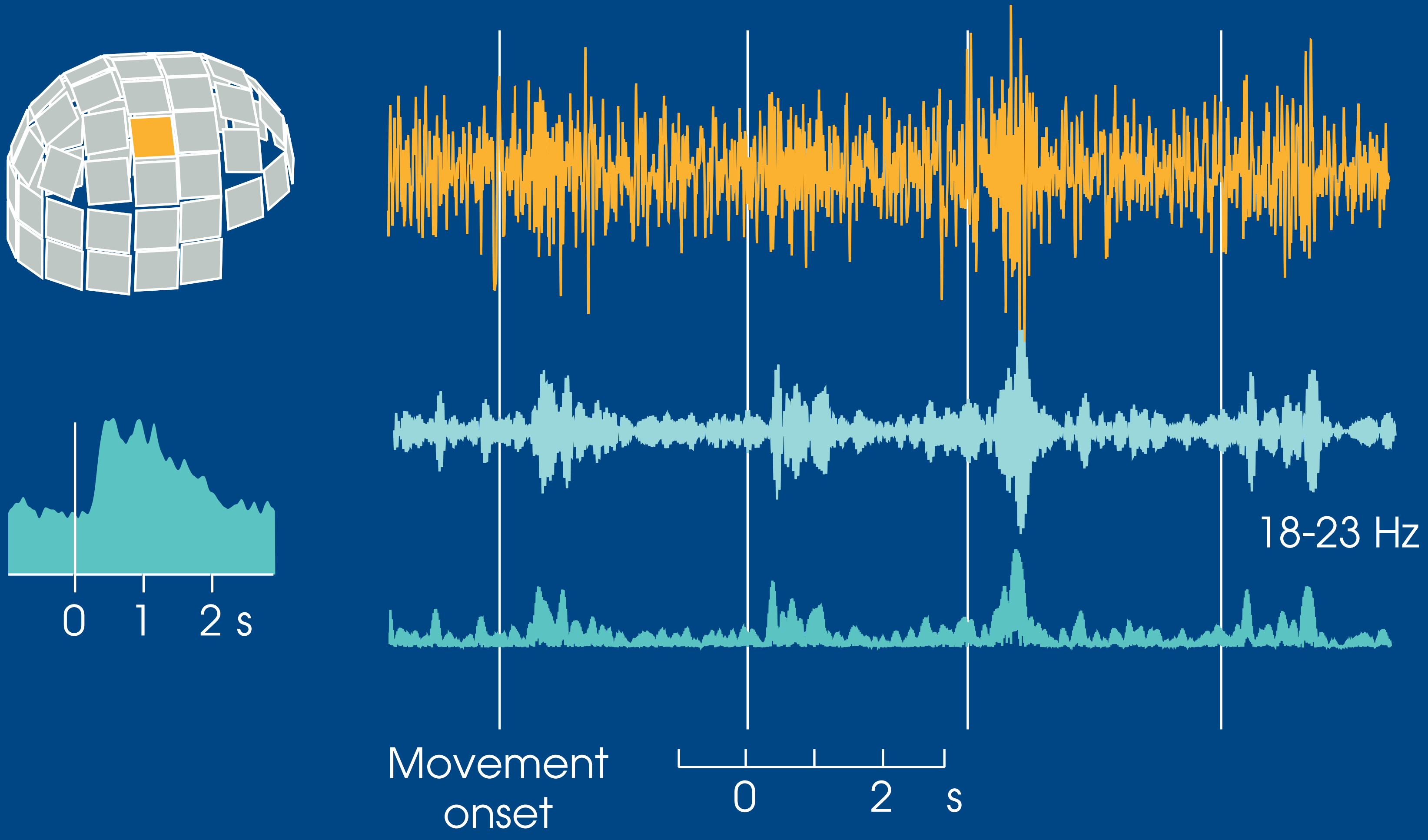
Salmelin, Hari, EEG J 1994

20-Hz Rhythm of the Motor Cortex



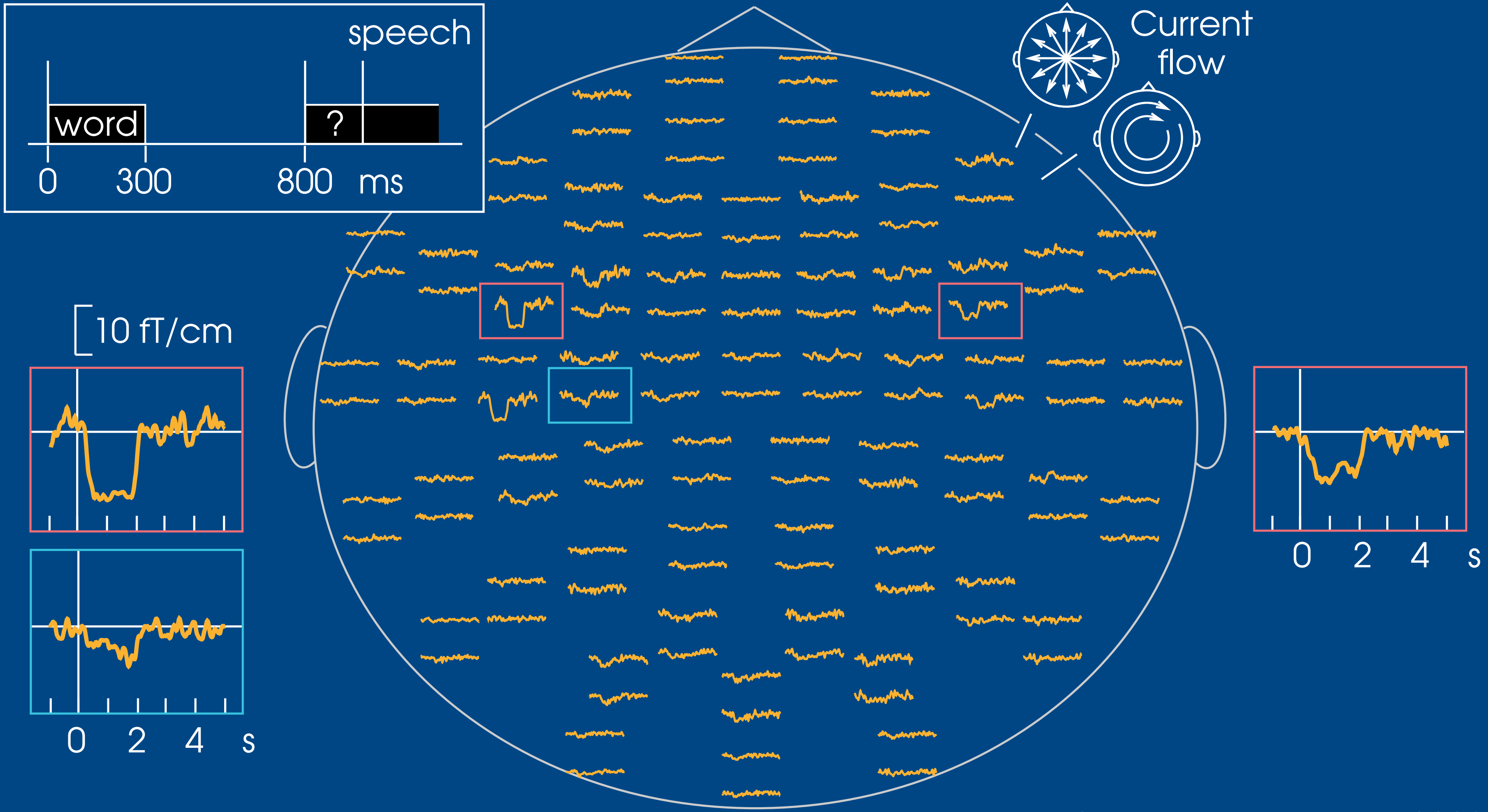
Salmelin et al., Neuroimage 1995

Temporal Spectral Evolution (TSE)



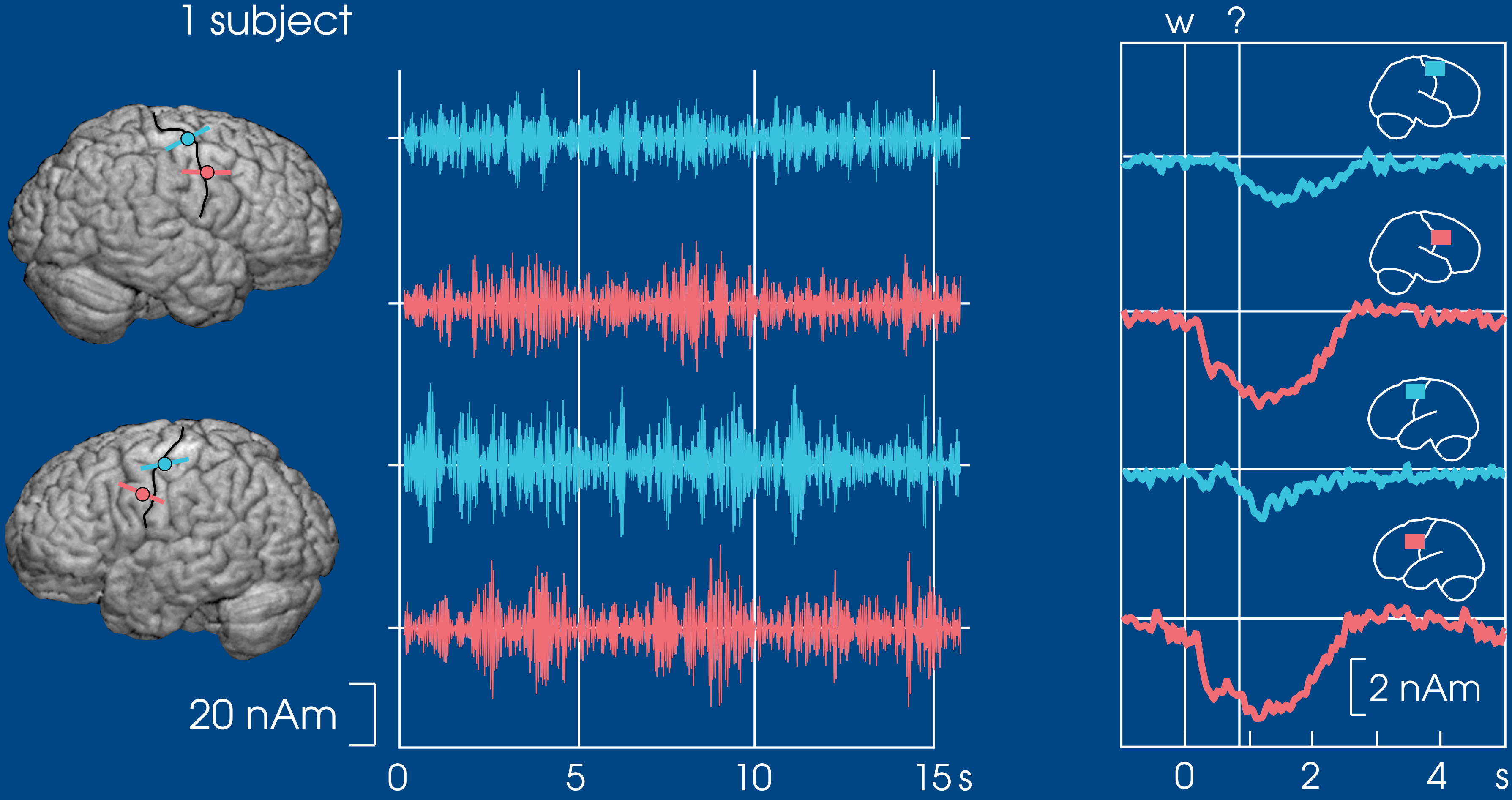
Salmelin et al., Neurosci 1994

Reading Words Aloud: Modulation of 20-Hz Rhythm



Salmelin et al., Brain 2000

Reading Words Aloud: Modulation of 20-Hz Rhythm



20-Hz source waveforms,
1 subject

Source 20-Hz TSE, 10 subjects

Salmelin et al., Brain 2000

Experimenter's Role in Data Collection and Analysis

Decide what you need to resolve & choose the paradigm
e.g. accurate localization with SEFs for presurgical mapping,
differences in timing during language tasks,
systematic change of parameters for functional localization,...

Make sure that your data is of highest quality (artefacts as well !)

ga$\int$rbage = garbage

KNOW your data throughout !

The proposed solution should be obvious also in the original signals

RS/Jun99

Which Analysis Tool to Choose ?

No miracle tools for 'correct' localization
= the inverse problem in MEG analysis

Automatic, user-independent analysis tools great for comparisons across sites and users but not more correct...

For good and clear data, any tool is fine – compare

Visual control of model and what it explains !

Caution in interpretation – true for all imaging techniques

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